Numerical Modeling of Pollution Formation in WTE Reactors using CFD

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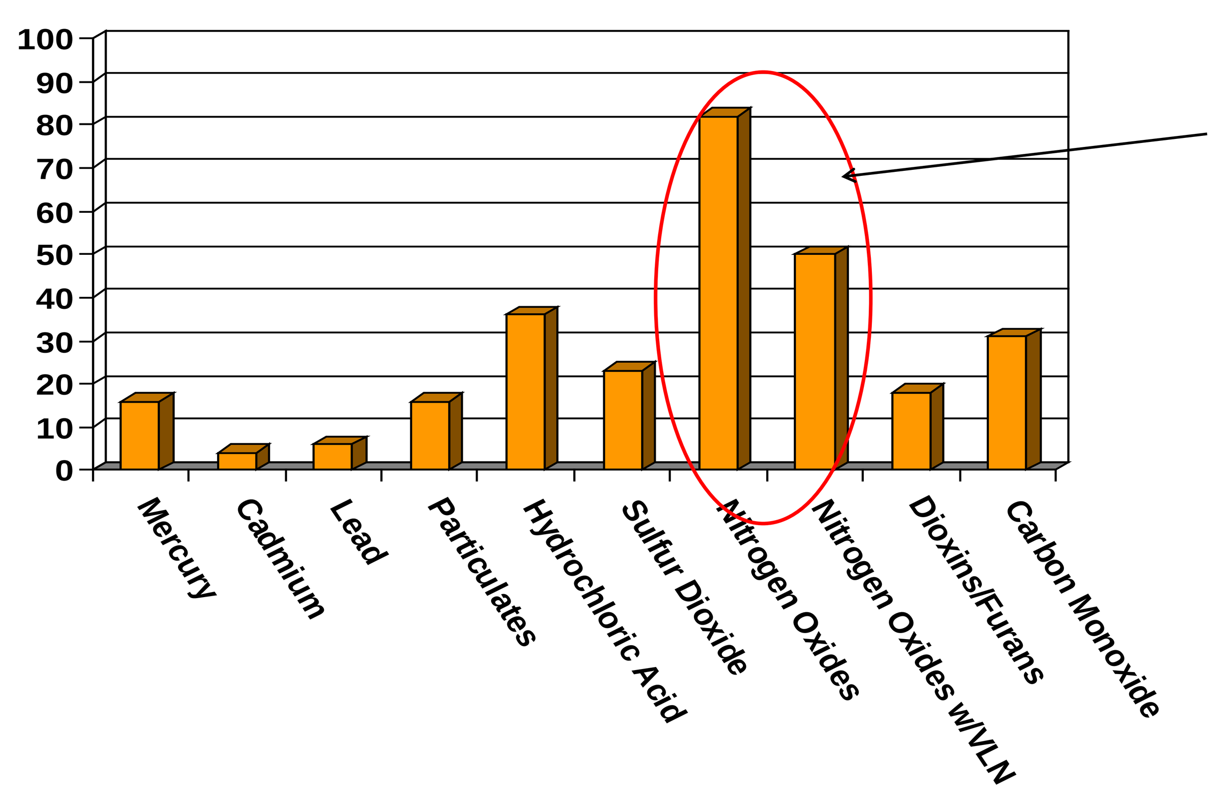
Background

*Limited WTE gas phase pollution modeling exists in the WTE industry
*Emissions reductions are usually based on field observations with little consultation of numerical models
*Modeling usually separates bed solid phase combustion and gas phase reactions
*Limited modeling of coupled solid/gas phase modeling exists
*Current modeling has limited capability in predicting No_x formation, a very important waste product



No_x Emissions are the Most Problematic

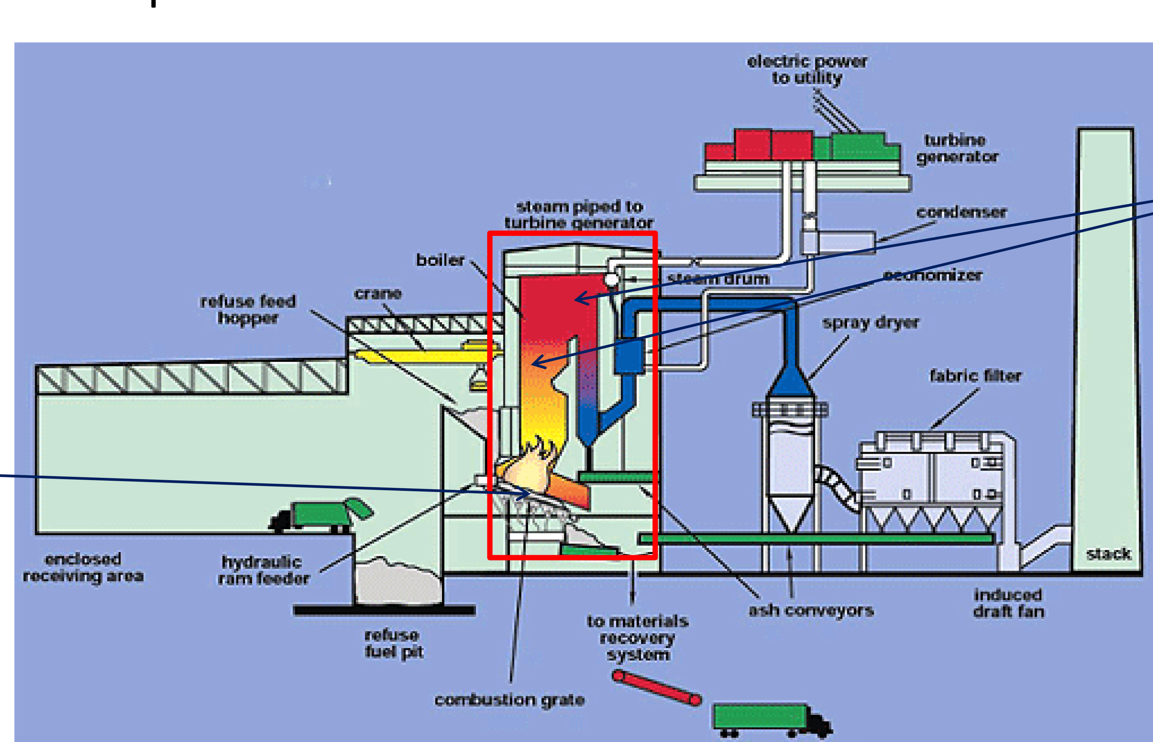
Figure 1: Covanta WTE Emissions vs. EPA MACT Limit %

*With ever increasing emissions standards as well as the increase in WTE energy generation around the world, understanding of pollution formation in operational systems is necessary to improve existing and new WTE systems.

Research Plan for Modeling

* Utilize existing WTE geometry and data of pollutants emitted
* Leverage CFD to predict pollution formation

Known Waste Composition



Measured Pollution Data will be used to Calibrate the Model

Figure 2: Schematic of WTE Plant

Research Plan for Modeling Cont.

*Develop reaction mechanism based on known inputs to data-match No_x, Particulate, CO, CO_2, and SO_2 emissions

$$C_xH_yO_z \bullet xH_2O + air$$

REACTION	A	b	E_a
139.[α] c2h4(+m)=c2h2+h2(+m)[β]	1.80E+13	0.0	76000.0
Low pressure limit:	2.60E+17	0.0	79289.0
140. c2h4(+m)=c2h3+h(+m)	2.00E+16	0.0	110000.0
Low pressure limit:	3.80E+17	0.0	98168.0
143. c2h3+o2=ch2o+hco	1.70E+29	-5.312	6500.0
144. c2h3+o2=ch2hco+o	3.50E+14	-0.611	5260.0
145. c2h3+o2=c2h2+ho2	2.12E- 06	6.0	9484.0
165. c2h2+o2=hcco+oh	2.00E+07	1.5	30100.0
207. hcco+o2=co2+hco	2.40E+11	0.0	-854.0
305. ac3h4+h=h2ccch+h2	2.00E+07	2.0	5000.0
307. ac3h4+oh=h2ccch+h2o	1.00E+07	2.0	1000.0
309. pc3h4+h=h2ccch+h2	2.00E+07	2.0	5000.0
311. pc3h4+oh=h2ccch+h2o	1.00E+07	2.0	1000.0
312. pc3h4+ch3=h2ccch+ch4	1.50E+00	3.5	5600.0
313. pc3h4+h=ch3+c2h2	5.12E+10	1.0	2060.0
329. h2ccch+h2ccch=c6h5+h	2.00E+12	0.0	0.0
332. chchcho+o2=c2h2+co+ho2	3.00E+12	0.0	0.0
342. c4h10=c2h5+c2h5	2.00E+16	0.0	81300.0
343. c4h10=nc3h7+ch3	1.74E+17	0.0	85700.0
344. pc4h9‡+h=c4h10	5.00E+13	0.0	0.0
345. sc4h9‡+h=c4h10	5.00E+13	0.0	0.0
346. c4h10+o2=pc4h9+ho2	2.50E+13	0.0	49000.0
347. c4h10+o2=sc4h9+ho2	4.00E+13	0.0	47600.0
348. c4h10+ac3h5=pc4h9+c3h6	7.94E+11	0.0	20500.0
349. c4h10+ac3h5=sc4h9+c3h6	3.16E+11	0.0	16400.0
350. c4h10+ch3=pc4h9+ch4	5.00E+11	0.0	13600.0
351. c4h10+ch3=sc4h9+ch4	4.30E+11	0.0	10500.0
352. c4h10+h=pc4h9+h2	2.84E+05	2.54	6050.0
353. c4h10+h=sc4h9+h2	5.68E+05	2.40	3765.0
354. c4h10+oh=pc4h9+h2o	4.13E+07	1.73	733.0

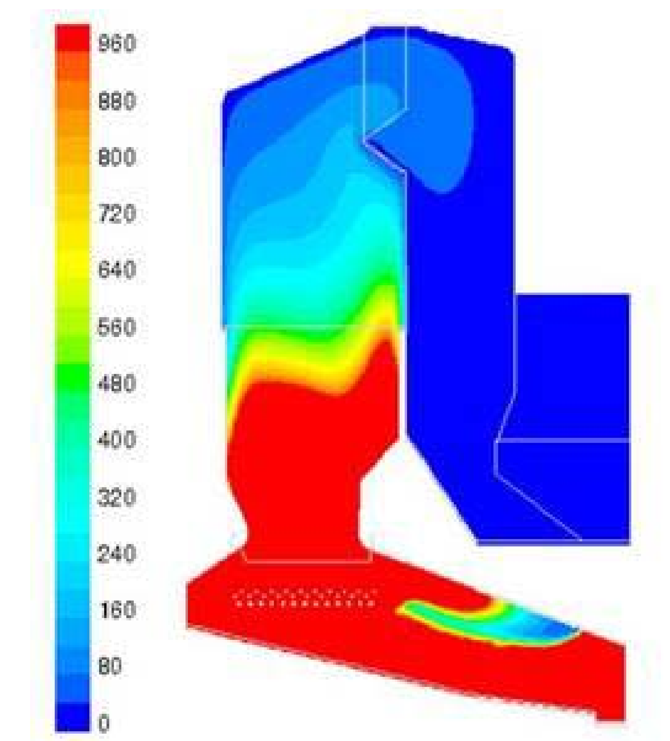


Figure 3: Contours of CO Formation

*Calibrate CFD model to measured data in order to ensure accuracy of modeling

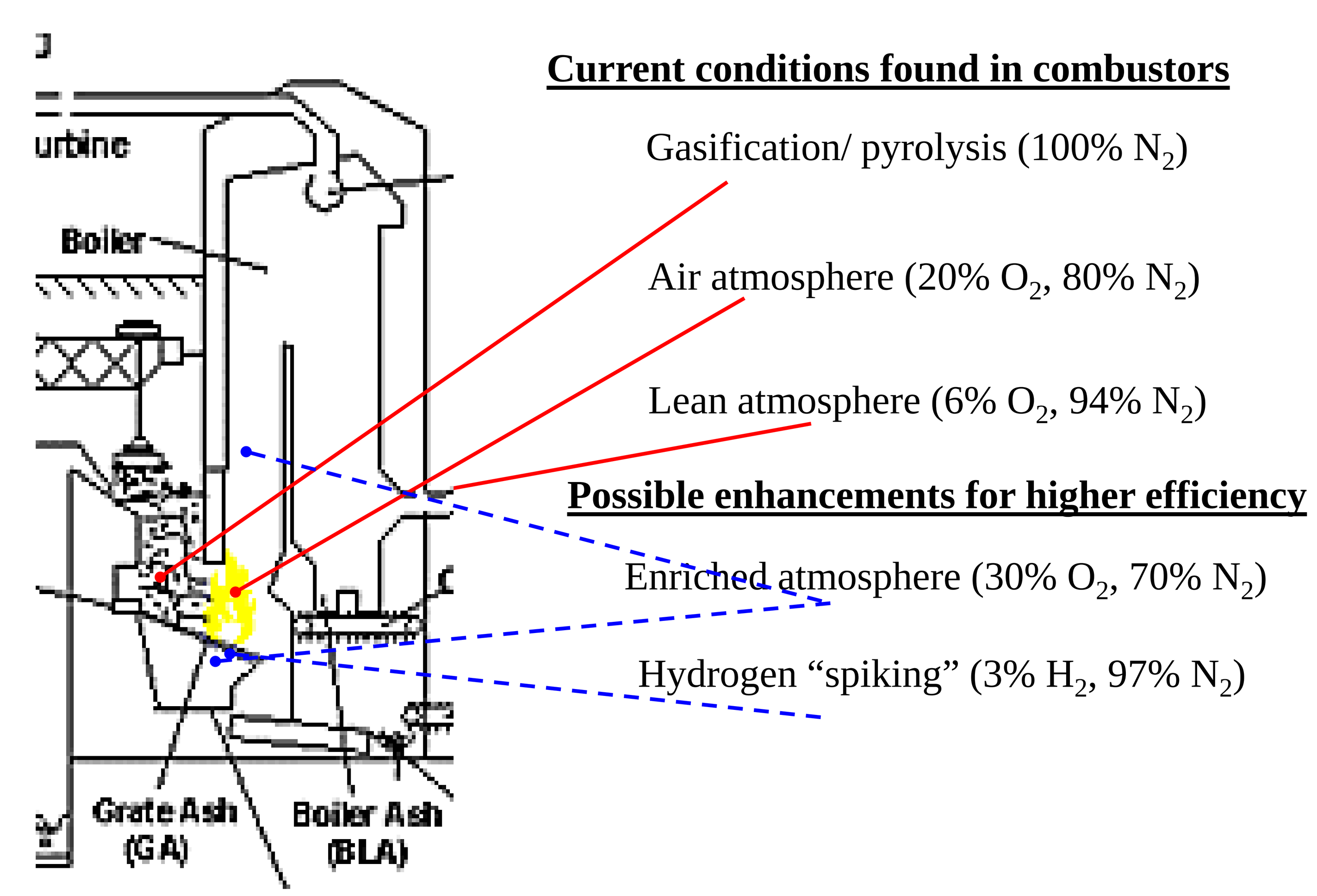


Figure 3: Possible Efficiency Improvements in WTE Reactors

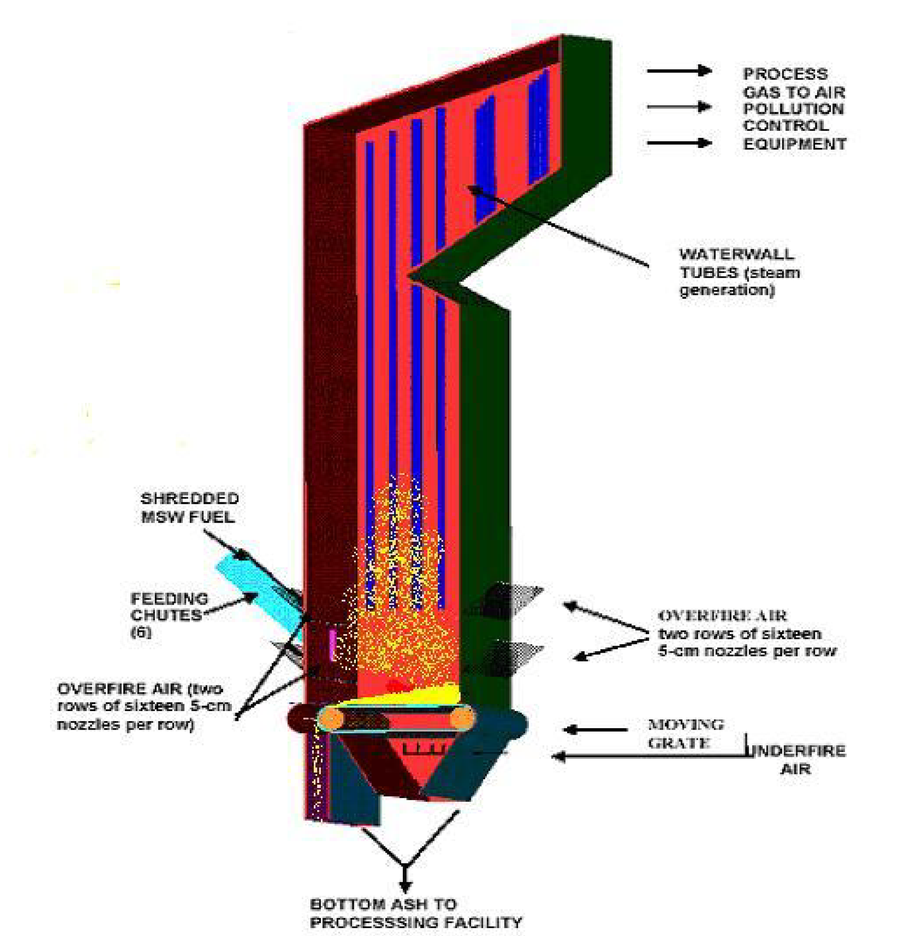


Figure 4: Modeling of Solid Phase Pre-Shredded MSW in CFD Model

*Once modeled and predicted values agree, alternate geometries and configurations will be studied in order to provide greater emissions reductions in the future